Adaptation strategies to address the potential impacts of climate change and variability on shellfish resources in Wellfleet Harbor

An overview prepared by the

Working group on Climate Change impacts on shellfishing in Wellfleet Harbor

July, 2015

Introduction

A key finding of a recent assessment of the northeastern US is that "heat waves, coastal flooding, and river flooding will pose a growing challenge to the region's environmental, social, and economic systems" (Horton et al. 2014, pg. 372). They will pose a particularly significant challenge to the shellfish sector in New England. Climate change and variability will have significant impacts on shellfish resources over the long term, as well as the communities that rely on them (Burkett and Davidson 2012, Ekstrom et al. 2015, Horton et al. 2014, Titus et al. 2009). Rising sea levels will alter shorelines, coastal ecology, and access to grants. Changing air and water temperatures and precipitation patterns will alter sea water quality, habitat, and work routines, as well as the prevalence of shellfish and human pathogens. Changes in water chemistry, most notably the risk of acidification, carry significant risks to shellfish and economies that rely on them. The frequency and intensity of harmful algae blooms are likely to increase. Changes in species composition are likely to result from a combination of multiple climate-related factors.

Shellfish are particularly vulnerable to climate change and variability. The National Marine Fisheries Service ranks shellfish as among the most vulnerable of fish stocks in the northeastern US (Griffis 2015). A preliminary assessment by the National Marine Fisheries Service concludes that exposure to climate change in Northeast U.S. is high to very high. The sensitivity of shellfish to climate stressors in the northeastern US is predicted to be high.

Shellfish resources are an important part of the environment (ecology is a study) of Wellfleet Harbor and the socio-economic health of the Town of Wellfleet. Shellfish help maintain water quality in the harbor and they are an important component of the overall ecosystem. While shellfish have historically played an important role in the local economy, the rise of shellfish aquaculture has given increased importance to this sector. Wellfleet produces approximately 20% of the shellfish harvest in the Commonwealth of Massachusetts, second to Duxbury. Landings in 2014 were valued at roughly $4,500,000.

Thus, threats, in the short-term and long-term, to shellfish and shellfishing in the Harbor are important to address proactively. In Wellfleet Harbor the main climate-related threats are: sea level rise, changes in intensity and frequency of heavy precipitation, rising water and air temperatures, and ocean acidification. Heavy precipitation events often occur in combination with storm surge and high winds, which can exacerbate impacts especially as sea levels rise. Shellfish play a vital role in nutrient cycling and trophic relationships in Wellfleet Harbor, and also in the economy of Wellfleet. There are two components to shellfish resources in Wellfleet Harbor, broadly speaking: the ecological system and the socio-economic system. These are connected, and are an example of a coupled socio-ecological system. The potential impact of climate change and variability on shellfish resources in Wellfleet Harbor are discussed in a separate report, *Potential impacts of climate change and variability on shellfish resources* (July 2015).

One way to respond to threats is to prevent or minimize their cause. This means reducing emissions of greenhouse gases that are the cause of climate change. While prevention should be the primary goal, it may no longer be feasible. Observers believe that some effects of climate change and variability are already being experienced in New England. Even if greenhouse gas emissions are significantly reduced in the short-term – a challenge both nationally and globally - impacts are likely to emerge and evolve over time. Consequently, communities like Wellfleet have time to plan and build capacities that enable people, communities, and businesses to adapt to a changing climate. This is referred to as adaptation.

This report identifies climate adaptation actions that can be taken to develop resilience and coping capacities related to the specific context of shellfish resources in Wellfleet Harbor.

These actions were identified by the Working Group on Climate Change impacts on shellfishing in Wellfleet Harbor. Information about the Working Group, including its goals and members, can be found in Appendix A and at the project website: www.seri-us.org/content/fisheries-and-climate-Wellfleet. The Working Group used the Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) process to organize its discussions (Webler et al. 2014; an overview is provided in Appendix A).

A matrix is used to organize information about a) how climate change might impact shellfish and shellfishers and b) actions that can be considered by the Town of Wellfleet Boards and Committees, state agencies, and federal agencies to adapt to new conditions and build resilience of shellfish and shellfishing to climate change. These actions are *not* prioritized or ranked. They are presented to further discussion within the Town about how to respond to climate change and variability.

Sea level rise, changes in intensity and frequency of heavy precipitation, rising water and air temperatures, and ocean acidification can impact the harbor, shellfish, and shellfishing directly. They can also lead to a series of outcomes including episodic flooding, chronic inundation, coastal erosion, saltwater intrusion, and increasing stormwater runoff that have the potential to impact shellfish and shellfishers in Wellfleet Harbor. Both direct and indirect outcomes of climate change may impact the Town and Harbor in other ways; the issue of shellfish is just one component of the overall socio-ecological system of which shellfishing in Wellfleet Harbor is a part. Adaptation actions may help address potential impacts to shellfish and shellfishers while at the same time helping to manage other potential impacts. These are often called "no regret" strategies because they may be worth doing no matter how severe the risks associated with climate change specifically.

Actions to address climate change and variability can be of three general types:

- Protective measures which seek to limit the impact of climate change through protective barriers and other infrastructure
- Accommodation which involves decreasing the potential for harm of, for example, sea level rise, warming water temperatures, and severe storms.
- Retreat refers to moving away from areas threatened, including moving structures and infrastructure.

Choices among these general strategies involve important trade-offs. Choices will impact different people or shellfish resources in different ways, and the distribution of these impacts will be important to consider. For example, costs and benefits of protective measures, accommodation, and retreat may be borne by different individuals or groups.

Actions to address climate change and variability can also be considered and implemented at different times to respond to emerging threats. In some cases, it is possible to wait so that more information can be obtained and the magnitude of threats and impacts are better understood. In other cases, actions are needed in the short-term to ensure that potential strategies are not foreclosed. Protection of open space to allow future marsh migration as a result of sea level rise is an example. Some decisions may also be needed in the short-term because their implications will have lasting effects, require substantial resources to implement, and are difficult to change once implemented. Communities that need to construct wastewater treatment plants face such a situation, since such facilities are expected to last for many decades. Construction of other types of infrastructure may fit into this category as well.

This report identifies adaptation actions that involve all types of strategies.

The role of the Wellfleet Selectboard

Homerule imparts significant responsibilities and authorities on the Wellfleet Selectboard. Recommendations by Town Boards and Committees to address the impacts of climate change and variability on shellfish resources in Wellfleet harbor can be implemented only with the support and action of the Selectboard.

The Working Group on Climate Change Impacts on Shellfishing in Wellfleet Harbor recommends that the Selectboard should:

1. Develop and implement a coordinated / comprehensive public education program about potential impacts of climate change and variability on Wellfleet harbor and the need for adaptation strategies.
2. Develop a strategic plan for climate adaptation based on recommendations of relevant Boards and Committees
3. Develop a strategic plan for coastal retreat on public properties, and develop incentives for structural adaptations and/or retreat on private properties.

Again, the Working Group on Climate Change impacts on shellfishing in Wellfleet Harbor focused on shellfish, rather than the broader and multiple ways that climate change may impact Wellfleet. Thus, these recommendations and the actions identified in the matrix focus on those related to shellfish. These actions should be integrated with a broader effort by the Town, starting with the Selectboard, to take local actions that can contribute to global mitigation of climate change, and particularly for Wellfleet, promoting coastal wetland restoration for restored carbon sequestration and reduced carbon dioxide and methane emissions from currently diked marshes.

Climate Change Outcomes	Implications for shellfish and shellfishers	Additional implications to community	Shellfish Advisory Board	Board of Health	Comprehensive Wastewater Management Planning Committee	Conservation Commission	Marina Advisory Committee	Natural Resource Advisory Board	Planning Board	State agencies (DMF, DPH, DEP, CZM)	Federal Agencies (NPS)
Episodic flooding of built environment (from storm surge and sea level rise)	• Damage to infrastructure • Contamination of shellfish	• Damage to property • Failure of septics • Contamination of harbor water • Contamination of wells	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement) • Recommend removal of man-made tidal restrictions	• Require septic upgrades (overtime) • Connect homes to municipal wastewater system • Recommend / promote alternative wastewater (septic) systems (other technologies) • Recommend removal of man-made tidal restrictions	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement) • Recommend / promote alternative wastewater systems (such as composting toilets, Nitrex barriers, and localized cluster wastewater systems) • Recommend removal of man-made tidal restrictions • Recommend improvements to stormwater run-off control • Recommend improvements to fertilizer controls	• Write orders of conditions for new buildings and septic systems • Increase protection of wetlands • Explore ability to enforce more restrictive regulations (than Wetlands Protection Act, no more armouring) • Recommend removal of man-made tidal restrictions	• Recommend removal of man-made tidal restrictions	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement) • Include strategies in Harbor Management Plan • Recommend removal of man-made tidal restrictions	• Improve drainage infrastructure • Retreat from coast • Educate public	• Establish policies that promote living shorelines (oyster reefs, salt marshes, seagrass beds) • Revise permitting policies	• Restore natural systems • Remove tidal restrictions

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Chronic inundation of built environment (from sea level rise)	• Damage to infrastructure • Impair access to grants • Contamination of shellfish • Increase incidence of shellfish disease • Reduced productivity of shellfish beds • Increased costs (gear, maintenance, boat, etc.) • More frequent algae blooms	• Damage to property • Increase nitrogen loading in harbor waters • Failure of septics • Harbor water contamination • Conflict between Harbor users • Conflict with marine mammals and sea turtles • Loss of natural water filtration • Harbor water contamination • Increased N loading • Loss of storm surge protection • Loss of habitat	• Recommend change location of grants	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement) • Connect homes to municipal drinking water • Require phased septic upgrades to reduce nitrogen loading • Connect homes to municipal wastewater system	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Protect wetlands • Write orders of conditions for new buildings and septic systems • Explore ability to enforce more restrictive regulations (than Wetlands Protection Act, no more armouring) • Recommend removal of man-made tidal restrictions	• Create more moorings, etc.	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Retreat from coast • Educate public	• Establish policies that promote living shorelines (oyster reefs) • Restore and protect marshes, eel grasses, and oyster reefs • Close shellfish beds	• Restore natural systems • Remove tidal restrictions

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Coastal erosion from storms with increased intensity	• Impair access to grants • Reduce harvestable areas • Reduce intertidal zone • Increased costs (gear, maintenance, boat, etc.)	• Property damage • Erosion of shoreline	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Protect wetlands • Evaluate policies for beach renourishment and recommend more environmentally safe strategies • Write orders of conditions for new buildings and septic systems • Evaluate and recommend soft solutions (rather than hard structures) for shoreline protection	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement) • Study and recommend strategies that allow for beneficial transport of sand	• Establish public land acquisition program for coastal protection • Establish fund for restoring and protecting marshes • Retreat from coast • Educate public • Purchase coastal lots	• Establish policies that promote living shorelines (oyster reefs) • Restore and protect marshes, eel grasses, and oyster reefs • Evaluate policies for beach renourishment and recommend more environmentally safe strategies • Study and recommend strategies that allow for beneficial transport of sand	• Remove tidal restrictions

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Saltwater intrusion	• More frequent algae blooms • Reduced productivity of shellfish beds • Increase incidence of shellfish disease • Increased costs	• Wells contaminated • Failure of septic systems • Harbor water contamination(what's intended here?) • Increased nitrogen loading	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Connect homes to municipal drinking water • Require septic upgrades (overtime) • Connect homes to municipal wastewater • Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement) • Limit development and use of GW	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	Write orders of conditions for new buildings Limit development and use of GW		• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Limit development and use of GW	• Restore salt marshes, oyster reefs, and eel grass	• Restore salt marshes, oyster reefs, and eel grass

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Increased surface water runoff from storms with increased intensity	• More frequent algae blooms • Reduced productivity of shellfish beds • Increase incidence of shellfish disease • Increased costs (gear, maintenance, boat, etc.) (How does runoff increase gear costs?) • More fecal coliform and more shellfish closures	• Harbor water contamination • Increased N loading • Decreased swimming water quality (fecal bacteria)	• Recommend treatment/filtration of surface runoff	• Recommend treatment/filtration of surface runoff	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement) • Recommend / promote alternative wastewater systems (such as composting toilets, Nitrex barriers, and localized cluster wastewater systems) • Recommend removal of man-made tidal restrictions • Recommend improvements to stormwater run-off control Recommend improvements to fertilizer controls	• Write orders of conditions for new buildings • Recommend treatment/filtration of surface runoff	• Recommend treatment/filtration of surface runoff	• Recommend treatment/filtration of surface runoff	• Recommend treatment/filtration of surface runoff	• Restore salt marshes, oyster reefs, and eel grass • Close shellfish beds • Promote treatment/filtration of surface runoff	• Promote treatment/filtration of surface runoff

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Warming water and air temperatures	• Increase in shellfish disease (non-human pathogens) • Increase in human pathogens • Reduced productivity of shellfish beds • Increased costs (gear, maintenance, boat, etc.) • Temporal mismatch of bivalve feeding & food abundance	• Decreased swimming water quality (bacteria)	• Ratchet up Vp management • Close recreational fishery in summer (Vp) • Hire more seasonal staff (Vp) • Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Restore living shorelines and marsh restoration		• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)		• Ratchet up Vp management • Close shellfish beds • Restore salt marshes, oyster reefs, and eel grass	• Restore salt marshes, oyster reefs, and eel grass
Changing water chemistry (pH)	• Reduced productivity of shellfish beds • Increase in shellfish disease (non-human pathogen) • Increase in human pathogens • Increased costs (gear, maintenance, boat, etc.) • Changes in phytoplankton species & abundance	• Decreased swimming water quality (prolonged fecal bacteria survival)	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)	• Protect and restore salt marshes		• Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)		• Restore salt marshes, oyster reefs, and eel grass	• Restore salt marshes, oyster reefs, and eel grass

References

Burkett, V.R. and Davidson, M.A. (Eds.) 2012. Coastal Impacts, Adaptation and Vulnerability: A Technical Input to the 2012 National Climate Assessment. Cooperative Report to the 2013 National Climate Assessment, pp. 150.

Ekstrom, J., Suatoni, L. Cooley, S., et al. 2015. Vulnerability and adaptation of US shellfisheries to ocean acidification, *Nature Climate Change* 5:207-214

Griffis, R.2015. *Steps toward Climate-Ready Fisheries Management*. Presentation at the National Adaptation Forum, 14 May 2015, St. Louis, MO. A similar presentation by Griffis et al. is available at: https://www.pices.int/publications/presentations/2015-Climate-Change/W5/W5-D1/1020-Griffis-Morrison.pdf

Horton, R., G. Yohe, W. Easterling, R. Kates, M. Ruth, E. Sussman, A. Whelchel, D. Wolfe, and F. Lipschultz 2014: *Chapter 16: Northeast. Climate Change Impacts in the United States: The Third National Climate Assessment*. In: J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe (Eds.). U.S. Global Change Research Program, pg. 371-395. Available at: http://nca2014.globalchange.gov/report/regions/northeast

Titus, J. G., Anderson, K. E., Cahoon, D. R., Gesch, D. B., Gill, S. K., Gutierrez, B. T., Thieler, E. R., and Williams, S. J. (eds.) 2009. *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid- Atlantic Region.* A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. U.S. Environmental Protection Agency, 320 pp. Available at: http://downloads.globalchange.gov/sap/sap4-1/sap4-1-final-report-all.pdf

Webler, T. Tuler, S. Dow, K. Whitehead, J., and Kettle, N. 2014. Design and evaluation of a local analytic-deliberative process for climate adaptation planning, *Local Environment: The International Journal of Justice and Sustainability*, Published online 17 Jul 2014: http://dx.doi.org/10.1080/13549839.2014.930425

Appendix A: Overview of Working Group and the VCAPS process

The **purpose** of the Working group on Climate Change impacts on shellfishing in Wellfleet Harbor is to identify:

- threats to shellfishing in Wellfleet Harbor from climate change,
- the role of shellfish in mitigating impacts from climate change and other environmental hazards in Wellfleet Harbor, and
- strategies to increase the resilience of Wellfleet and its shellfishery in a time of climate change.

The **outcome** of the working group will be reports summarizing threats and opportunities, including specific actions that the Town and others can consider further to manage threats to the shellfishery in both the short and longterm. Specifically, the Working Group will provide information to inform local planning by addressing these questions:

1. What are anticipated impacts in Wellfleet Harbor and to shellfish from climate change?
2. To what extent do existing plans and proposed actions address impacts in Wellfleet Harbor and to shellfish from a changing climate? (Harbor Plan, Shellfish Management Plan, etc.)
3. What information is needed to understand impacts and how they can be managed (reduce vulnerabilities, adapt, etc.)?
4. What are additional / new actions that can be taken to reduce vulnerabilities and increase resilience of Wellfleet Harbor and its shellfish to a changing climate?

Members of the Working group on Climate Change impacts on shellfishing in Wellfleet Harbor

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Further information is available at: www.seri-us.org/content/fisheries-and-climate-Wellfleet

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